2. Ground Water/Vadose Zone Monitoring Strategies for Early Alert of Potential Contaminant Migration

MONITORING: MONITORING ACID DRAINAGE
Bennett, John, ANSTO, Managing Mine Wastes Project
Groundwork, No 1 Vol 2, Sep 1998 (Available online at http://www.ameef.com.au/groundwk.htm)

A key aim of the management of sulphidic mine wastes is to limit ecological detriment to acceptable levels. Monitoring of existing sulphidic waste piles (waste rock dumps and tailings dams) can provide information on the production and transport of pollutants. This information enables management decisions to be made about the need for control measures. Where controls have been put in place, monitoring enables their effectiveness to be quantified. Monitoring can also provide data for use in predicting medium to long term behavior of waste piles. With any monitoring program, it is always important to have in mind the questions that the measurements are designed to answer. While techniques for monitoring processes and mechanisms in tailings dams are well-established, adequate monitoring of waste rock dumps presents much more of a problem. Major difficulties arise because waste rock is highly unsaturated. The need to understand the hydrology of, and chemical transport in, waste rock dumps stimulates active research programs. This paper summarizes current techniques for monitoring acid drainage sites.

AN ASSESSMENT OF ACID ROCK DRAINAGE CONTINOUS MONITORING TECHNOLOGY
Fytas, K.; J. Hadjigeorgiou
Environmental Geology, Vol 25 No 1, p 36-42, 01 Feb 1995

THE USE OF INVERTEBRATES IN GROUND WATER MONITORING: A RISING RESEARCH FIELD
Malard, Florian (University of Lyon, Villeurbanne, France); S. Plenet; J. Gibert
Ground Water Monitoring and Remediation, Vol 16 No 2, p103-113, Spring 1996

A number of groundwater quality monitoring programs have begun utilizing invertebrates as biomonitors. Case studies of four field biomonitoring programs are used to illustrate the benefits offered by these techniques for a range of hydrogeological settings. A scarcity of insect species in some regions of the Rhone River indicated that the interstitial zone of the river had been heavily contaminated with heavy metals. The low relative abundances of stygobites compared against populations of stygoxenes and stygophiles resulted from sewage pollution entering the saturated zone of a karstic aquifer. These types of assessment methods can be refined and applied to a range of contamination situations or combined with standard pollution monitoring strategies.

GUIDELINE DOCUMENT FOR MONITORING ACID MINE DRAINAGE
MEND Secretariat CANMET, Ottawa, Ontario. MEND Project 4.5.4, Oct 1997

This guideline document is designed to serve as a single source introductory guide to a wide range of AMD monitoring concerns, while also providing users with information on the latest and most valuable literature sources for more site-specific concerns and emerging monitoring techniques. The document is structured to provide a guide for the design and implementation of monitoring programs from the

perspective of the development of a new mine. The recognition of AMD potential and the integration of AMD monitoring within the overall environmental monitoring program during the pre-operational phase will minimize AMD effects and optimize sampling and cost efficiency. Additional information is provided for currently operating or decommissioned mines which face AMD concerns. AMD monitoring requirements are addressed for both Source and Receiving environments, with receiving environment concerns restricted to freshwater systems. The source environment is defined as the potential freshwater contaminant pathways between the source of AMD generation and the designated point of release to the environment, which usually consists of the furthest downstream water quality compliance station. The receiving environment consists of the freshwater environment downstream (or down-gradient) of the water quality compliance stations.

ENVIRONMENTAL MONITORING OF URANIUM MINING WASTES USING GEOPHYSICAL TECHNIQUES

MEND Secretariat CANMET, Ottawa, Ontario. MEND Report MA-1, Feb 1996

Monitoring of contaminants, from uranium mine waste management facilities, is primarily done by drilling test holes and installing piezometers to sample the subsurface soil and the groundwater. Protocols using geophysical methods of monitoring the migration of acidic leachate from uranium mine waste rock piles and tailings facilities need to be developed. Shallow surface geophysics that include methods such as Electromagnetic (conductivity) and DC Resistivity surveys are less expensive, can locate contaminant plumes both laterally and with depth, providing an areal "snapshot" of the site at any given time. Cluff Lake Mine, a wholly owned project of Cogema Resources Inc. of Saskatoon was selected as the research demonstration site. To study the effects of acidic mine drainage a multi-year program is envisioned. The first phase, the subject of this report, involved the testing of various off-the-shelf electromagnetic and resistivity equipment over several site locations. Additional
phases are required to monitor temporal changes by carrying out repeat surveys to verify the first phase results. Other methods such as ground penetrating radar may be used to supplement the conductivity and resistivity surveys.

INTERNET CASE STUDY FOR MARCH 1999: ONSET OF ACIDIC DRAINAGE FROM A MINE-ROCK PILE

Morin, K.A.; Nora M. Hutt

In studies of acidic drainage, a "lag time" between near-neutral conditions and the onset of net-acidic drainage is well recognized, generally ranging from a few days to more than 15 years. However, the manner in which the onset occurs, such as smoothly or erratically, in full-scale minesite components in not well documented. This Internet Case Study shows how one mine-rock pile evolved from near-neutral-pH to acidic conditions, and then highlights the geochemical indicators warning of that impending onset of acidic drainage. The North Dump (approximately 84x106 metric tonnes of rock and till) at the Island Copper Mine in British Columbia showed that the onset of acidic conditions involved a time period of significant fluctuations in pH and concentrations, from a few years (Monitoring Station EDD) to perhaps a decade or more (Station NDD). These fluctuations were apparently due to variable contributions and conditions in upstream pathways according to the conceptual model. At Island Copper, all upstream pathways in the North Dump were expected to eventually become acidic, so drainage was expected to become consistently acidic. At other minesites, some pathways may remain near neutral indefinitely so that ongoing fluctuations in water chemistry may become a long-term feature rather than an

eventual onset of constant net acidity. Monitoring of aqueous sulphate at minesites with sulphide-bearing rock may provide warnings of any impending onset of acidic drainage, with sufficient response time to install remedial or control measures. This case study of the North Dump showed that sulphate concentrations increased significantly, by a factor of two, about two years before the first appearance of acidic water (pH < 6.0). However, sulphate will not act as a reliable indicator if its concentrations are limited by solubility of minerals like gypsum, because the concentrations would not reflect actual reaction rates inside the mine-rock pile. For additional information: http://www.mdag.com/cs3-99.htm

INTERNET CASE STUDY FOR SEPTEMBER 1999: MINE CLOSURE AND LONG-TERM CONTROL OF ACIDIC DRAINAGE AT ISLAND COPPER MINE, BRITISH COLUMBIA, CANADA
Morin, K.A.; N.M. Hutt

The Island Copper Minesite is located on the northern end of Vancouver Island, in the Canadian Province of British Columbia. The layout and drainage chemistry of this site are described in the March 1999 Internet Case Study entitled Onset of Acidic Drainage from a Mine-Rock Pile. For additional information: http://www.mdag.com/cs9-99.htm

HIGH-FREQUENCY GEOCHEMICAL MONITORING OF TOE SEEPAGE FROM MINE-ROCK DUMPS, BHP MINERALS' ISLAND COPPER MINE, BRITISH COLUMBIA
Morin, K.A.; I.A. Horne; D. Riehm
Third International Conference on the Abatement of Acidic Drainage, 24-30 Apr 1994, Pittsburgh, Pennsylvania
Report No: BUMINES-SP-06A-94. NTIS: PB96-113519NEG. Vol 1, p 346-354, 1994